Patent KOKAI No. 1-223943

Title of the invention: Receptor of Nuclear Magnetic Resonance Imager

Claim:

(1) In a receptor of high frequency electromagnetic wave of a nuclear magnetic resonance imager comprising a pre-amplifier (2) which amplifies a high frequency electric signal received by a receiving coil (400) and a main amplifier (6) which converts the frequency of an output signal from the pre-amplifier (2) into an intermediate frequency and further amplifies the signal, the receptor being characterized in that comprising;

electricity-light converting means which converts the output signal from said pre-amplifier (2) into a light signal,

light transmitting means (42) which transmits the light signal converted by said converting means and

light-electricity converting means (5) which converts the light signal transmitted from said transmitting means (42) into an electric signal,

an output signal from said light-electricity converting means (42) is used as an input signal to said main amplifier (6),

a solar battery (3) which generates and provides direct current electric power as a direct current power to said pre-amplifier (2) and a light emitting source (32) which generates light for irradiation to the solar battery (3),

said solar battery (3), said pre-amplifier (2) and said electricity-light converting means (4) are contained in a common case, the surface of the case is provided at least partially a light receiving surface, and the receiving surface is irradiated with light generated by said light emitting source (32).

Drawings:

Fig. 1 is a circuit of the embodiment of the present invention.
Fig. 2 is a perspective view of respective coils of MRI apparatus, and
Fig. 3 is a circuit of conventional receiver.

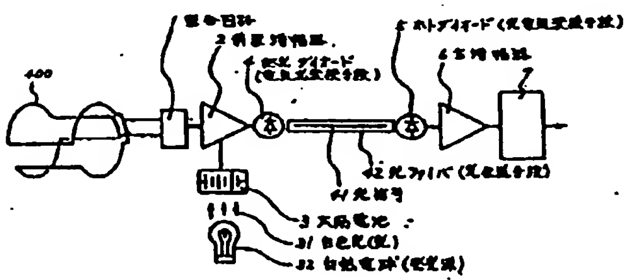

Fig. 1

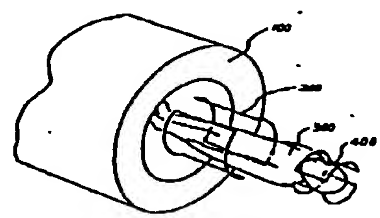

Fig. 2

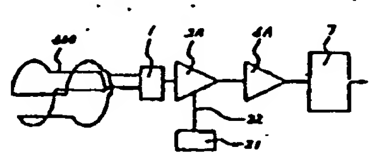

Fig. 3

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RECEIVING DEVICE OF NUCLEAR MAGNETIC RESONANCE TOMOGRAPHIC DEVICE

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[There are no amendments to this patent.]

Claim

A type of receiving device of a nuclear magnetic resonance tomographic device characterized by the following facts: the receiving device of a nuclear magnetic resonance tomographic device is composed of a preamplifier that amplifies the RF electrical signal received by the receiving coil and a principal amplifier which converts the output signal of said preamplifier to a medium frequency and which further amplifies the frequency-converted signal; in this receiving device of a nuclear magnetic resonance tomographic device, there are the following means: an electro-optical converting means that converts the output signal of said preamplifier to an optical signal, an optical transmission means which optically transmits the optical signal converted by said electro-optical converting means, and an opto-electrical converting means that converts the optical signal transmitted by said optical transmission means to an electrical signal; the output signal of said opto-electrical converting means is taken as the input signal of said principal amplifier; the DC power source of said preamplifier is composed of a photovoltaic cell which generates the DC power to be supplied and a light source that generates light irradiating the photovoltaic cell; said photovoltaic cell is accommodated together with said preamplifier and said electro-optical converting means in a common case; at least a part of the surface of the case is made the light receiving surface of said photovoltaic cell; and the light generated by said light source irradiates said light receiving surface.

Detailed explanation of the invention

Industrial application field

This invention pertains to a type of receiving device of RF electromagnetic waves of a so-called MRI device, which makes use of the nuclear magnetic resonance phenomenon to take tomographic pictures of a human body or other object.

Prior art

The receiving coils of the MRI device include a transceiving coil that acts as receiving coil for obtaining the tomographic picture of human body, a dedicated receiving coil known as a body coil which is attached to a part of the object for obtaining a detailed tomographic image of a part of the object, and a receiving coil dedicated to the head region.

When the head region has brain tumor or other major disease, it is necessary to take a reliable picture. Consequently, the receiving coil should be set as near the head region as possible. On the other hand, for the transceiving coil, a high voltage of several kilovolts is applied, and it should be set as far away from the object as possible. In consideration of these two facts, a receiving coil dedicated to the head region is used to take tomographic pictures of the head region.

Figure 2 is a diagram illustrating the various types of coils in an MRI device. In this figure, principal coil (100) is a coil which generates a uniform static magnetic field of 0.1 T in the center of principal coil (100) when a conventional electroconductive coil is used, or of about 1 T with a superconductive coil. In this uniform magnetic field, by means of transceiving coil (200), an RF electromagnetic field is applied so that nuclear magnetic resonance takes place, and the resonant nuclei emit RF electromagnetic waves, which are received by the receiving coil. The resonance frequency of the nuclei depends on the type of nuclei, and it is proportional to said uniform magnetic field intensity. For example, when hydrogen nuclei are in a uniform magnetic field of 1 T, the resonance frequency is about 43 MHz.

When tomographic pictures of the body of the patient are taken, transceiving coil (200) acts as a receiving coil, and said transceiving coil (200) is used to receive said RF electromagnetic waves. When tomographic pictures of the head region are taken, the head is placed in the space with the uniform magnetic field, RF electromagnetic wares are transmitted by transceiving coil (200), and waves are received by receiving coil (400) dedicated to the head region.

In this figure, the coil depicts different positions of the human body in the axial direction. However, when a tomographic picture of the head region is to be obtained, principal coil (100), transceiving coil (200), receiving coil (400) and the head of the patient are all placed in the uniform magnetic field, in practice.

The receiving coil receives the electromagnetic waves emitted by the resonance energy of the nuclei in resonance after completion of transmission of the RF electromagnetic waves, due to nuclear magnetic resonance of the hydrogen atom nuclei of the human body under the RF electromagnetic waves transmitted by the transmitting coil. Depending on the system, the electromagnetic waves known as spin echoes or PID signals have very low intensity. Consequently, it is necessary place the transceiving system of the RF electromagnetic wave in an environment with little noise, and, at the same time, the minute electrical signal received by the receiving coil should be amplified with low noise. The signal-to-noise ratio in the receiving device part is an important factor in determining the image quality of the MRI device. In consideration of this fact, the preamplifier that first amplifies the electrical signal received by the receiving coil should be a low-noise amplifier, and, at the same time, the constitution should be such that noise invading from the outside is significantly suppressed.

There are two major routes [sic; sources] for noise invading from the outside. One source is electromagnetic waves transmitted through space. The counter measure for this problem is an electromagnetic shield that covers the object, the receiving coil, and the preamplifier. The other source of noise is RF current that enters through the cable from the DC power source of the

preamplifier. Also, as the cable of the DC power source also picks up RF noise at the same time, it plays the role of an antenna, and the signal-to-noise ratio decreases.

Figure 3 is a circuit diagram illustrating a conventional receiving device. The RF electrical signal received by receiving coil (400) goes through matching circuit (1) made of two capacitors connected in tandem in the circuit and becomes the input signal of preamplifier (2A). As this electrical signal is weak on the order of μV, it is necessary to amplify the signal by preamplifier (2A) to the desired intensity without a decrease in the signal-to-noise ratio. As the capacitors that form matching circuit (1) are small, these capacitors are placed in receiving coil (400). Also, preamplifier (2A) is placed very near the receiving coil. In the construction, preamplifier (2A) is fixed to receiving coil (400) and they are integrated with each other. By setting matching circuit (1) and preamplifier (2A) near the receiving coil (400), it is possible to shorten the wiring of the input circuit of matching circuit (1) and preamplifier (2A) as much as possible, so that pickup of external noise by the circuit wiring can be reduced. The DC power source of preamplifier (2A) is fed from DC power source (21) through cord (22). Usually, said cord (22) is made of coaxial cable so as not to pick up external noise.

As principal amplifier (6A), not shown in Figure 2, placed beneath the bed carrying the object, coaxial cable is used to connect preamplifier (2A) and principal amplifier (6A) at a position about 1 m away from the center of principal coil (100) where the receiving coil is placed.

After amplification by preamplifier (2A), the electrical signal on the order of mV is input to principal amplifier (6A). In said principal amplifier (6A), the input electrical signal is converted to a medium frequency, and it is then further amplified to an electrical signal on the order of a few V as required for A/D converter (7) that converts the signal to a digital signal for input to computer.

Problems to be solved by the invention

As the RF signal received by he receiving coil is weak, it is necessary to amplify the weak electrical signal first to a necessary intensity by the preamplifier. In order to amplify the signal to the desired level, the amplification of the preamplifier should be high. The cable connecting the output side of the preamplifier to the principal amplifier acts as an antenna and it emits RF electromagnetic wave to the surrounding space. The RF electromagnetic wave is received by wiring of the input circuit of the preamplifier, and it is fed back from the output side of the preamplifier to the input side to form a feedback circuit. Also, as the amplification of the preamplifier is high, the feedback effect is high, and this causes intermodulation distortion in the output signal of the preamplifier. This is a problem. In addition, external noise invades from the

DC power source preamplifier feed cable, so that the signal-to-noise ratio of the preamplifier further decreases.

The purpose of this invention is to provide a type of receiving device which can prevent external noise from invading and has a sufficiently high amplification in the preamplifier to have the desired output signal intensity, and which has an excellent signal-to-noise ratio and is free of intermodulation distortion caused by feedback from the preamplifier output signal.

Means to solve the problems

In order to solve the aforementioned problems, this invention provides a type of receiving device of a nuclear magnetic resonance tomographic device characterized by the following facts: the receiving device of a nuclear magnetic resonance tomographic device is composed of a preamplifier that amplifies the RF electrical signal received by the receiving coil and a principal amplifier which converts the output signal of said preamplifier to a medium frequency and which further amplifies the frequency-converted signal; in this receiving device of a nuclear magnetic resonance tomographic device, there are the following means: an electro-optical converting means that converts the output signal of said preamplifier to an optical signal, an optical transmission means which optically transmits the optical signal converted by said electro-optical converting means, and an opto-electrical converting means that converts the optical signal transmitted by said optical transmission means to an electrical signal; the output signal of said opto-electrical converting means is taken as the input signal of said principal amplifier; the DC power source of said preamplifier is composed of a photovoltaic cell which generates the DC power supply and a light source that generates the light irradiating the photovoltaic cell; said photovoltaic cell is accommodated together with said preamplifier and said electro-optical converting means in a common case; at least a part of the surface of the case is used as the light-receiving surface of said photovoltaic cell; and the light generated by said light source irradiates said light receiving surface.

Operation

In the constitution of this invention, as the current consumption of the preamplifier is small, a photovoltaic cell is used as the DC power source for the preamplifier. Also, as a dedicated light source is used to emit light to supply the desired electrical power, there is no need for a photovoltaic cell with a large area, and a steady power supply can be produced. Because there is no need for a power source cord from the outside, external noise entering through the power source cord disappears. In addition, because the electrical signal output from the preamplifier is converted to an optical signal by the electro-optical converter to produce the output signal of the preamplifier, no RF electromagnetic wave in the vicinity is generated by the

output signal. Consequently, there is no feedback to the input side. Consequently, even when the amplification of the preamplifier is selected to be as high as desired, intermodulation distortion still does not occur.

Application examples

In the following, this invention will be explained in more detail with reference to application examples. Figure 1 is a circuit diagram illustrating an application example of this invention. As the same part numbers as those for the prior art have been adopted, they will not be explained in detail again. The RF electrical signal received by receiving coil (400) is sent as input signal to preamplifier (2) through matching circuit (1). The output signal of said preamplifier (2) drives light-emitting diode (4), as the electro-optical converting means, to generate optical signal (41). Said optical signal (41) is transmitted through optical fiber (42) serving as optical transmission means to irradiate photodiode (5), and is converted to an electrical signal. This electrical signal is taken as the input signal to the principal amplifier, and, after amplification by principal amplifier (6), it becomes the input signal to A/D converter (7). As the DC power source of preamplifier (2), photovoltaic cell (3) is used, and, as white light (31) emitted by a dedicated incandescent lamp (32) irradiates photovoltaic cell (3), the desired electrical power can be steadily supplied. Both light-emitting diode (4) and photovoltaic cell (3) are accommodated together with preamplifier (2) in a common case. The light-receiving surface of photovoltaic cell (3) is made part of the surface of the case, and white light (31) from incandescent lamp (32) is concentrated for high-efficiency irradiation. Consequently, the surface area of photovoltaic cell (3) required to generate the necessary electrical power can be reduced, and, at the same time, electrical power can be supplied steadily.

As the output signal of preamplifier (2) is converted to optical signal (41) by means of the light emitted by light-emitting diode (4), the cable that connects the preamplifier to the principal amplifier can be omitted. Consequently, the cable does not pick up external noise. Also, there is no intermodulation distortion caused by feedback that would otherwise occur with the cable acting as a transmission antenna emitting RF electromagnetic waves to the surrounding space and with the RF electromagnetic waves being received by the input circuit wiring of preamplifier (2).

As photovoltaic cell (3) is used as the DC power source of preamplifier (2), and white light (31) emitted from an electric bulb or the like irradiates the photovoltaic cell, the prescribed electrical power is supplied steadily to photovoltaic cell (3). In this system, there is no need to have a cable for the DC power source of preamplifier (2). Consequently, there is no noise entering through the cable, and the noise characteristics of preamplifier (2) are improved.

Optical signal (41) is transmitted to principal amplifier (6) set about 1 m away through optical fiber (42). The location of principal amplifier (6) is remote from the space with RF electromagnetic waves, and this location can be well shielded from the electromagnetic field. Consequently, the principal amplifier, as the circuit after photodiode (5) that converts optical signal (41) to an electrical signal, can be made a low-noise amplifier free of influence from external noise or RF electromagnetic waves. In this application example, optical transmission means (42) is an optical fiber. Use of an optical fiber in transmission of optical signals is a well-known technology, as optical communication is now so popular. In the receiving coil used in this invention, as explained above, a transceiving coil and a head-dedicated receiving coil are included. Their positions of use are the prescribed positions in which their centers are aligned with the uniform magnetic field generated by principal coil (100). Consequently, the light emitting position of the optical output signal of preamplifier (2) is also defined uniquely for each receiving coil. Consequently, it is also possible to use the space within principal coil (100) as the optical transmission means to the light receiving part, instead of using an optical fiber as the optical transmission means. It is also possible to construct an effective optical transmission means by aligning the optical axes of the light emitting part and light receiving part, at the same time making use of a lens to focus the light of the optical signal emitted from the light emitting part on the light receiving part.

In the aforementioned application example, the light source for the photovoltaic cell is an incandescent lamp. However, the light source is not limited to an incandescent lamp. Other types of light source may also be used, keeping in mind the optical wavelength characteristics of the photovoltaic cell.

Effect of the invention

According to this invention, as explained above, the electrical signal which is the output signal of the preamplifier is converted to an optical signal, and optical transmission carries it to the principal amplifier. Consequently, intermodulation distortion caused by feedback from the cable for transmitting the preamplifier output signal to the principal amplifier can be prevented. Also, a photovoltaic cell is used as the DC power source of the preamplifier, and the photovoltaic cell is accommodated together with the preamplifier and the aforementioned photodiode in a common case, with the light emitted from the light source irradiating the light receiving part of the photovoltaic cell. Consequently, the desired electrical power can be steadily supplied, so that it is possible to prevent reduction of the signal-to-noise ratio of the preamplifier caused by the cable from the DC power source picking up noise. In this way, in the RF amplifier, which should be taken as the heart of the MRI device, the signal-to-noise ratio can be increased significantly. Consequently, a high-performance MRI device with excellent image quality can be obtained.

Brief description of the figures

Figure 1 is a circuit diagram illustrating an application example of this invention. Figure 2 is an oblique view of the various coils in the MRI device. Figure 3 is a circuit diagram illustrating a conventional receiving device.

1	Matching circuit
2, 2A	Preamplifier
3	Photovoltaic cell
31	White light (light)
32	Incandescent lamp (light source)
4	Light-emitting diode (electro-optical converting means)
41	Optical signal
42	Optical fiber (optical transmission means)
5	Photodiode (opto-electrical converting means)
6, 6A	Principal amplifier
400	Receiving coil

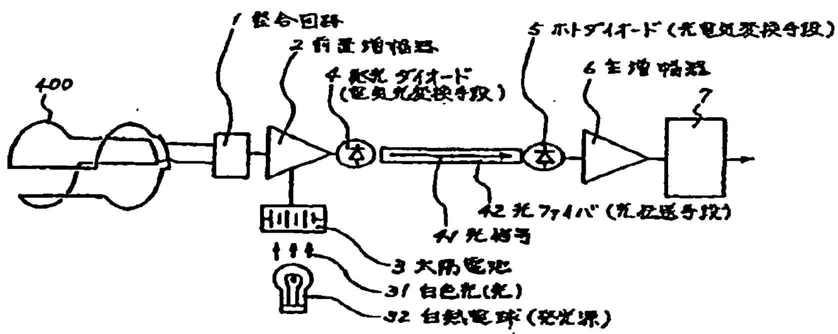

Figure 1

Key:

1	Matching circuit
2	Preamplifier
3	Photovoltaic cell
31	White light (light)
32	Incandescent lamp (light source)
4	Light-emitting diode (electro-optical converting means)

41 Optical signal
42 Optical fiber (optical transmission means)
5 Photodiode (opto-electrical converting means)
6 Principal amplifier

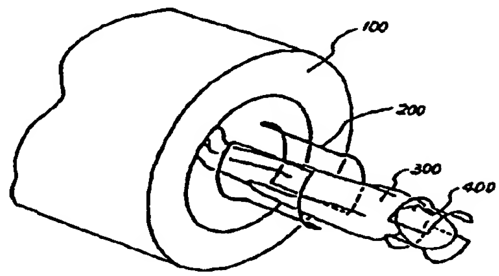

Figure 2

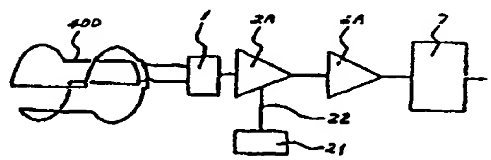

Figure 3